

UNIVERSITY OF CALIFORNIA  
COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION  
BERKELEY, CALIFORNIA

CIRCULAR 315

JULY, 1929

# THE MEDITERRANEAN AND OTHER FRUIT FLIES

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The purpose of this publication is to give a brief account of the more important fruit flies that may be introduced and become serious pests in California, with particular reference to the Mediterranean fruit fly and how to distinguish this species from other insects which occur in the state in sound or decayed fruits.<sup>2</sup>

Fruit flies include certain species of two-winged flies of the family Trypetidae whose larvae live in a wide range of fruits, nuts, and vegetables. The more important genera of these flies and their origin are as follows:

GENUS	SUPPOSED ORIGIN	MOST IMPORTANT SPECIES
1. <i>Ceratitis</i> .....	Equatorial Africa.	<i>C. capitata</i> Wied., Mediterranean fruit fly
2. <i>Dacus</i> .....	Equatorial Africa.	<i>D. oleae</i> Rossi, olive fly
3. <i>Bactrocera</i> .....	Indo-Australian.....	<i>B. cucurbitae</i> Coq., melon fly
4. <i>Anastrepha</i> .....	Tropical America.....	<i>A. ludens</i> Loew, Mexican fruit fly <i>A. fraterculus</i> , West Indian fruit fly
5. <i>Rhagoletis</i> .....	North America.....	<i>R. pomonella</i> Walsh, apple maggot <i>R. cingulata</i> Loew <i>R. fausta</i> O. S. Cherry fruit flies

The following species occur in California:

*Rhagoletis juglandis* Cress., walnut husk fly

*Epochra canadensis* Loew, currant fruit fly

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<sup>2</sup> Several sources of information have been drawn upon and particularly that of E. A. Back and C. E. Pemberton in publications of the United States Department of Agriculture.

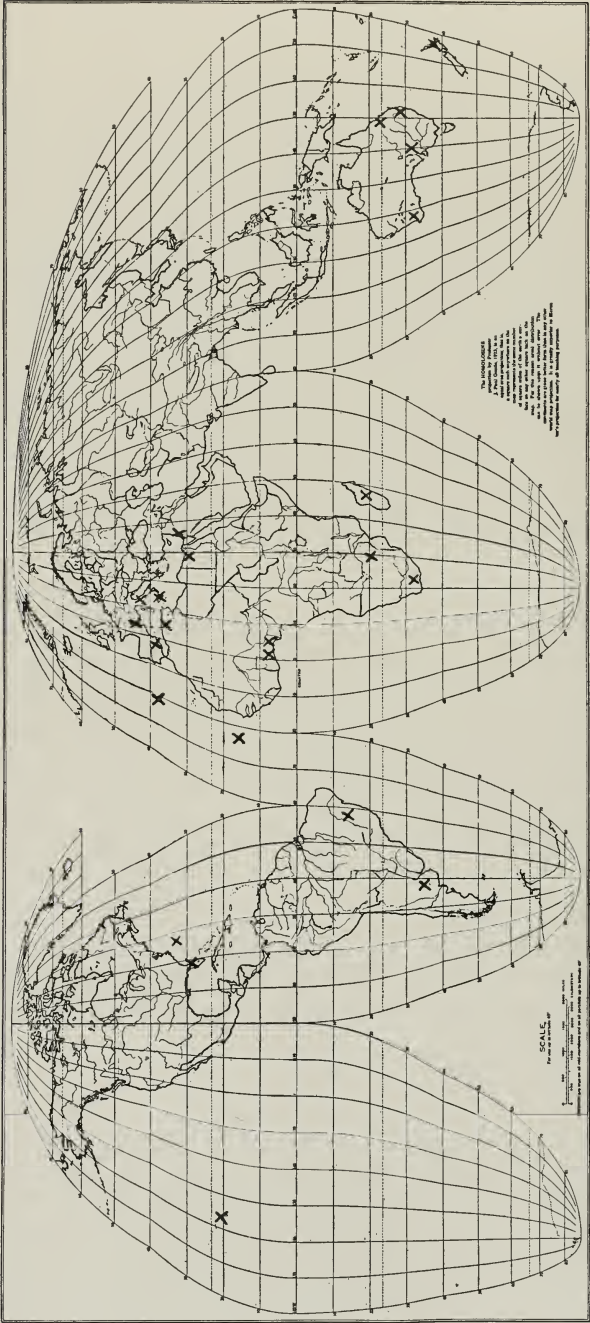


Fig. 1.—Map of the world showing distribution of the Mediterranean fruit fly.

Common insects other than trypetids occurring in California and likely to be mistaken for the Mediterranean fruit fly are the scavenger flies and scavenger beetles. The scavenger flies occurring in decayed fruits in California are:

*Euxesta notata* Wied.

*Lonchaea occidentalis* Malloch.

*Drosophila ampelophila* Wied.

The scavenger beetle in decayed fruits in California is *Carpophilus hemipterus* Linn.

### THE MEDITERRANEAN FRUIT FLY

#### *Ceratitis capitata*

*Distribution and Status as a Pest.*—This species is the most destructive of all of the fruit flies because of its wide range of hosts and its wide distribution (fig. 1) in tropical and subtropical countries. It has been known in the Mediterranean countries since 1842, in South Africa since 1889, in Australia since 1887, in Bermuda since 1865, in Hawaii since 1910, and during the present year (1929) it has been found in Florida.

The Mediterranean fruit fly is an important pest on both deciduous and citrus fruits, but in regions where deciduous fruits constitute an important crop it is a more serious pest on these fruits than on citrus. This is due to the fact that most citrus fruits mature during the cooler part of the year when the fly is less active, or inactive, while most deciduous fruits mature in the warmer portion of the year when the fly is most active, and also to the fact that there is a greater mortality of the younger stages of the fly in the case of citrus fruits. Such summer-maturing citrus fruits as the Valencia orange, however, as well as other citrus fruits growing in warm climates, may be subject to severe infestation.

*What the Mediterranean Fruit Fly Looks Like.*—The adult Mediterranean fruit fly may be readily distinguished by examining plate 1. It is a little smaller than the house fly, with colors of brown, yellow, black, and white arranged in the characteristic pattern as shown. There are two white bands on the yellowish abdomen, yellow, brown and black markings on the wings, and black areas on the back. The wings are normally held in a drooping position.

The larva (figures 2, 3, 4, and 6) when full grown is a little over  $\frac{1}{4}$  of an inch long and ordinarily of a cream color, but this color

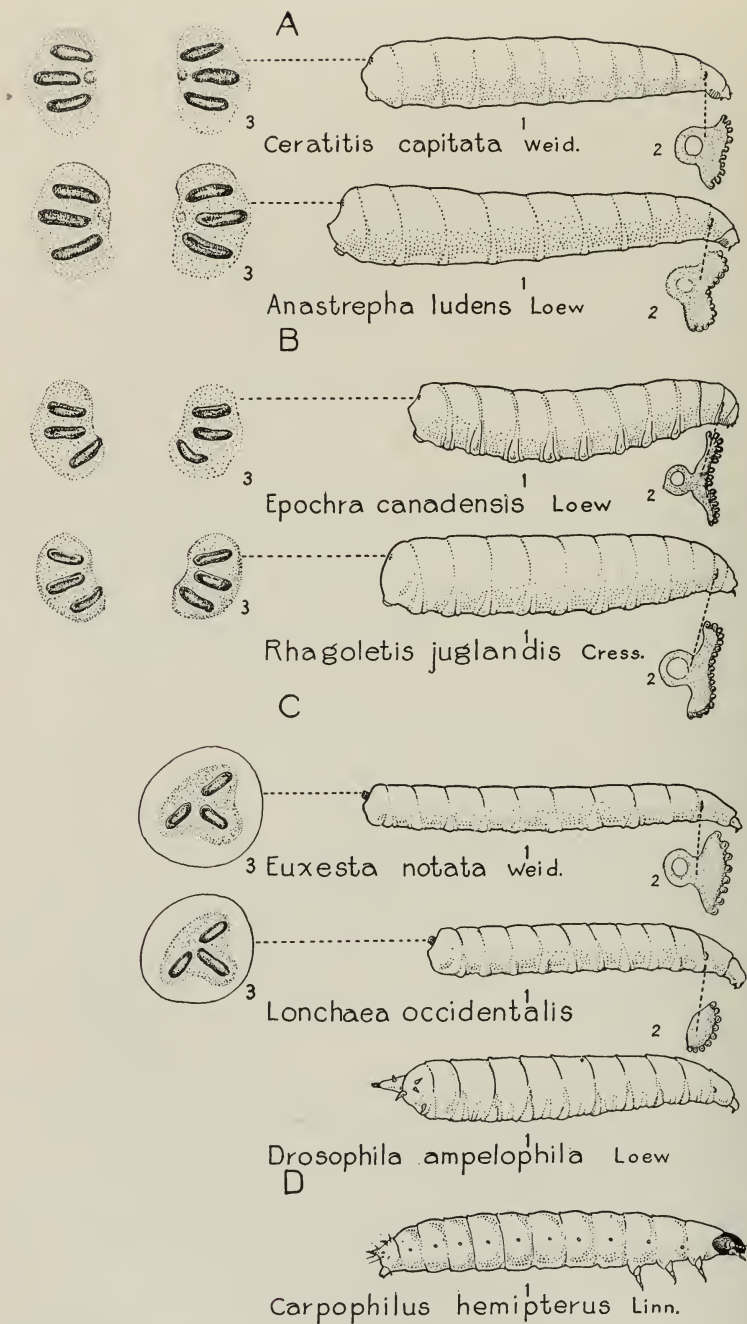


Fig. 2. (Explanation on bottom of page 5.)

varies somewhat in different fruits. It is sluggish in its movements, but when full grown it has the habit of arching its body and from this position it is capable of jumping as far as 4 or 5 inches. Upon examination with a hand lens the posterior spiracles may be seen as six oval-shaped structures of a brown color and arranged in two groups of three set crescent-shaped opposite each other. These spiracles are set flush with the surface and not on the end of a stalk as with most of the common dipterous scavenger larvae that may be found in decayed fruits in California. Final determination of the larva, however, should be left to competent authorities and the instructions followed as given on page 17.

The pupa (fig. 3) looks somewhat like a swollen grain of wheat with rounded ends and a series of rings running around the body. The color varies from straw to dark brown.

The eggs are white in color,  $\frac{1}{27}$  of an inch long, and pointed at each end.

*How the Mediterranean Fruit Fly Lives.*—The female fly makes a puncture with its ovipositor in the rind or skin of the fruit and in a cavity beneath the surface it deposits from 1 to 6 eggs. Other flies may deposit eggs in the same cavity until as many as 25 or 30 may be deposited through one puncture in the rind. A single fly may lay as many as 600 or 800 eggs.

Upon hatching the larva burrows directly into the pulp of the fruit upon which it feeds. The time spent in the fruit will vary from a week to three or four weeks according to the temperature. When full grown the larva drops to the ground, if the fruit has not already fallen, and buries itself in the soil to the depth of from one to three or four inches. Transformation to the pupa then takes place, and it remains in this stage from one to three weeks. But soil is not at all necessary since pupation may occur anywhere in the open. The adult fly makes its way out of the puparium and up through the soil with the aid of the ptilinum, a bladder-like organ on the head capable of expansion and contraction. The adult fly feeds from four days to a week or more before depositing any eggs. This is the vulnerable

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Fig. 2.—A, Fruit-fly larvae not in California. The Mediterranean fruit fly, *Ceratitis capitata* and the Mexican fruit fly, *Anastrepha ludens*. 1, larva; 2, anterior spiracle; 3, posterior spiracle.

B, Fruit-fly larvae in California. The current fruit fly, *Epochra canadensis* and the walnut husk fly, *Rhagoletis juglandis*.

C, Scavenger fly larvae in fruits in California. *Euxesta notata*, *Lonchaea occidentalis*, *Drosophila ampelophila*.

D, Scavenger beetle larva in fruits in California. The dried-fruit beetle, *Carpophilus hemipterus*.



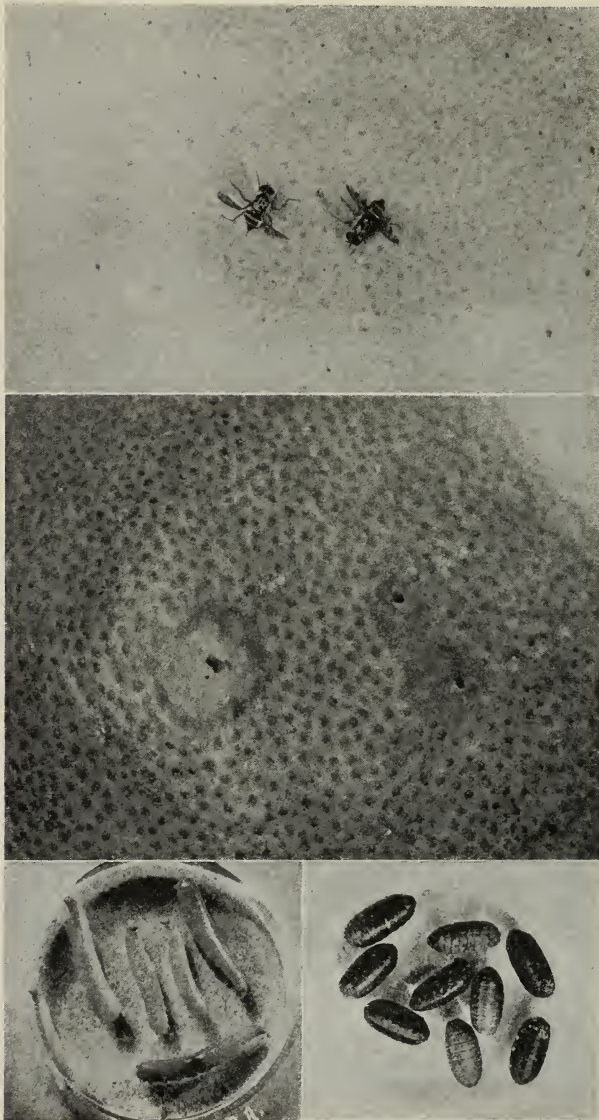


Fig. 3.—Top, two Mediterranean fruit flies in natural position on grapefruit. Center, external appearance of grapefruit infested with Mediterranean fruit fly. Bottom, left, larvae, and right, pupae, of Mediterranean fruit fly. (Photo by Wooten.)

point of attack by means of a sweetened poison spray. The fly will not live longer than three or four days without food. Subsistence is dependent chiefly upon insect and plant exudations. With proper food and deprived of suitable material in which to deposit eggs the fly will live as long as six or eight months.

*Hosts of the Mediterranean Fruit Fly.*—There are upwards of 120 different species of fruits, nuts, and vegetables listed as hosts in which the larva may develop. Many of these records, however, have been secured under more or less artificial conditions. Peaches, figs,



Fig. 4.—Larva of Mediterranean fruit fly in an orange, Spain.

plums, and apricots are among the more severely infested deciduous fruits. In Florida the grapefruit is most susceptible of the citrus fruits. Florida is the first region the fly has invaded where grapefruit is an important commercial crop. All varieties of citrus, of course, are hosts of the fly, and under proper conditions are heavily infested. Such vegetables as tomatoes, peppers, egg plant, beans, cantaloupes, and others may be infested but the Mediterranean fruit fly is primarily a pest of fruits, while the melon fly is more important on vegetables. Of the field crops, cotton may be attacked after an injury to the boll that will furnish a suitable place for the fly to deposit its eggs. A complete host-list is not given because new host plants are being continually added and all fruit-like parts of plants may be regarded as possible occasional hosts. The pineapple is one of the fruits that is exempt from attack.

*When Fruits Are Attacked.*—The Mediterranean fruit fly shows a strong preference for mature fruits. In the Mediterranean countries oranges are not infested until they reach a stage of maturity that is indicated by at least a partial orange coloring. Sometimes eggs will be deposited in immature fruits, but the larvae fail to hatch because of gum formation or for some other reason. If egg punctures are made in such fruits as the papaya a milky secretion interferes with the development of the eggs, and in other fruits other



Fig. 5.—Work of Mediterranean fruit fly in a lemon, Sicily.

secretions tend to increase the mortality, if not to check the development of the fly. In fruits such as peaches, however, eggs will be deposited and develop while they are still green. The fly will develop in many overripe or partially decayed fruits which are immune until they have reached this condition. This is true of the papaya and certain varieties of bananas in the Hawaiian Islands, and the lemon in the Mediterranean countries. There seems to be no fruit that is too acid to prevent the development of the larva. The lemon (fig. 5) was supposed to be immune in the Mediterranean countries, because of its acidity, but the author demonstrated that the larva in any stage could be transferred from a ripe peach to a green lemon with no interruption in its development. But all of the lemons found infested, normally, in the Mediterranean countries were badly broken down by decay. Consequently, the nature of the rind or skin of fruits



seems to be more important in limiting the development in certain fruits, or in other fruits at certain seasons, by affecting the deposition of eggs or the establishment of the young larvae, than the nature of the flesh or pulp that serves as food.

*What Infested Fruits Look Like.*—Egg punctures made by the fly are not easily detected at first, but a slit in the skin soon becomes visible and as the larvae hatch and begin feeding the egg puncture is enlarged to admit air. Sometimes the puncture appears as a small nipple, particularly in oranges, and the surrounding surface forms a

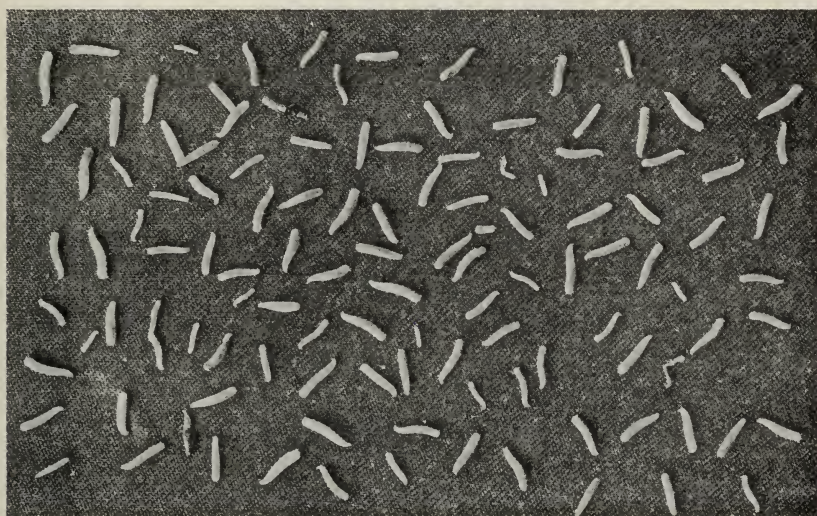


Fig. 6.—One hundred and eighteen larvae of Mediterranean fruit fly taken from a single orange, Sicily.

depression. After the larvae feed for a short time and consume the pulp below, a softening occurs at that point which can be detected by pressing the fruit, and often juices will exude from the enlarged puncture. Decay soon sets in and a brown area appears around the point of infection (fig. 3, center). As the feeding of the larvae and the decay continue, the fruit is likely to drop prematurely and, in the case of many fruits, certain to drop eventually if there are many larvae in a single fruit.

*Status as a Pest in Different Countries.*—The importance of the Mediterranean fruit fly as a pest is dependent primarily upon two factors, namely, a variety of host plants and favorable climatic conditions. If there are few hosts and these are subject to attack for but a short season, a sufficient population will not be built up to con-

stitute a serious pest. If, on the other hand, there are many hosts and there is a long favorable season the population of the fly will be increased to such numbers as to be a serious pest.

The latter conditions are furnished in Hawaii and only to a slightly less extent in Florida. In the Mediterranean countries and South Africa and most of Australia there is a winter period of more or less length when the fly is inactive. Such fruits as certain varieties of citrus that mature during this season largely escape attack. There is also a heavy mortality of the adult flies in regions where there is a well-defined winter season, and it is not until late summer or fall that a large population of flies occurs.

Where there is a distinct winter season, of course, there are fewer host plants. In respect to climatic and host-plant conditions California may be compared very closely with some of the Mediterranean countries, as well as parts of Australia and South Africa. We are, justified, therefore, in assuming that if the fly became established in California its status as a pest would be similar to that in some of the Mediterranean countries and parts of Australia and South Africa and quite different from that of Hawaii and Florida. But in spite of some natural restrictions on the fly in California as compared with Florida and Hawaii, it would constitute a most serious pest on practically all of the major fruits in the state.

#### OTHER FOREIGN FRUIT FLIES WHICH MIGHT PROVE TO BE SERIOUS PESTS IF INTRODUCED

*The Mexican Fruit Fly* (*Anastrepha ludens* Loew).—The Mexican fruit fly (fig. 7) has long been a serious pest of citrus, mangoes, and other fruits in Mexico. In 1925 it was found in the lower Rio Grande Valley in Texas. A campaign of eradication was immediately inaugurated and for two years the fly was not seen. In 1929, however, the fly reappeared in a few places, owing no doubt to the fact that the host-free period which was included in the eradication campaign was extended one month later in the spring. It was during this month that the new infestations were found. The situation at present (June, 1929) seems to be very well in hand and there is every reason to believe that it will be eradicated.

The life history and habits of this species in general are similar to that of the Mediterranean fruit fly. The adult is readily distinguished by reference to figure 7. The full-grown larva of this species is larger than that of the Mediterranean fruit fly, but since younger

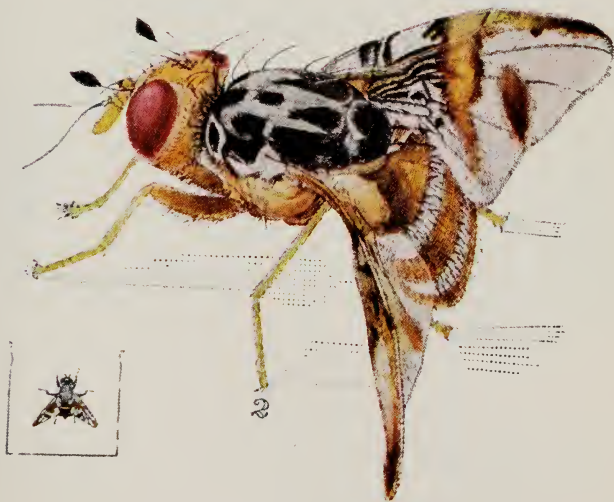
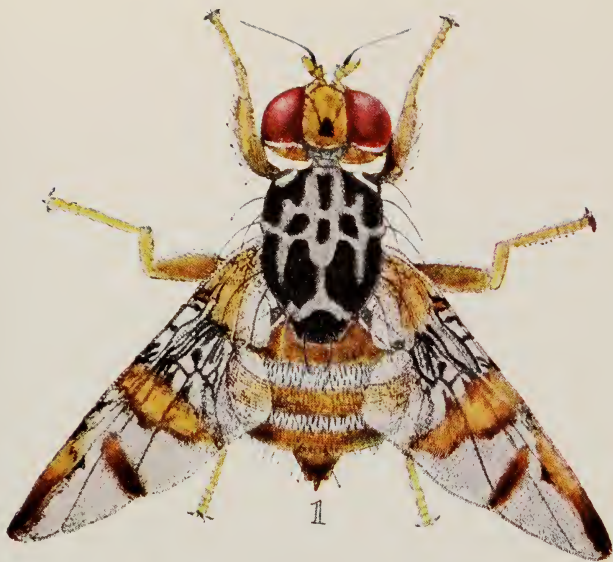


Plate 1.—The Mediterranean fruit fly, showing the colors and pattern. Female above, male below. The characteristic position of the wings is as shown in the lower figure.





larvae may be of the same size, the two are not readily distinguishable. Reference to figure 2A will show that the anterior spiracles of *Anastrepha ludens* have from 13 to 14 tubules while in *Ceratitis capitata* the number is usually less, although there is greater variation. In *C. capitata* there may be as few as 8 or 9 and as many as 13 or 14. The tubules in *A. ludens* are more bead-like while in *C. capitata* they appear as longer projections.



Fig. 7.—Mexican fruit fly, *Anastrepha ludens* Loew. 1, male; 2, female; 3, pupa; 4, larva. (After Isaac.)

*Anastrepha ludens* was formerly thought to be limited to the warmer parts of Mexico, such as the state of Morelos, and it was formerly known as the Morelos orange maggot, but it is now known that it will thrive in the lower Rio Grande Valley of Texas and it is possible that parts of southern California would not be unsuitable to it.

*The West Indian Fruit Fly* (*Anastrepha fraterculus* Wied).—The West Indian fruit fly is widely distributed in the West Indies, Mexico, Central America, and South America. It attacks the peach, pear, plum, persimmon, orange, guava, mango, coffee cherries, and other

tropical and subtropical fruits. Its distribution in South America would indicate it might be an important pest in California. The larva of this species has from 15 to 17 tubules on the anterior spiracles while in *A. ludens* there are but 13 to 14.

*The Melon Fly (Bactrocera cucurbitae Coq.).*—The melon fly (fig. 8) occurs in India, Ceylon, Java, Australia, Philippine Islands, southern China, Malay States, Japan, and the Hawaiian Islands. It attacks melons of all kinds, tomatoes, string beans, cow peas, egg plant, and certain fruits. While its distribution is generally limited to regions of a more tropical climate than that of California, the fact

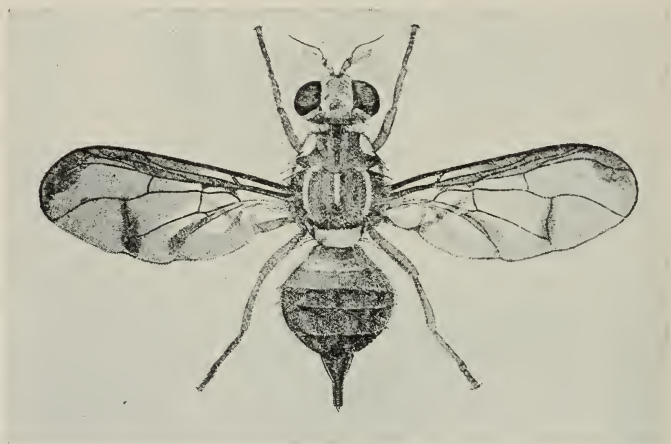


Fig. 8.—Melon fly. *Bactrocera cucurbitae* Coq. (After Back.)

that it has been taken at Nagasaki in Japan and is known to attack cucurbits on the Island of Formosa may indicate that it could gain a foothold in California.

*The Olive Fly (Dacus oleae Rossi).*—The olive fly (fig. 9) occurs in all of the countries bordering on the Mediterranean and in South Africa and Western Asia. It is a serious pest of olives, to which host and closely related species it is restricted. Most of the olives attacked fall to the ground before reaching maturity. In the case of this fly mature fruit is not at all necessary for infestation.

Infested olives may be distinguished by a circular area on the surface that is of a light gray color. Before entering the pupal stage, in the case of green fruits, the larva eats a channel to the surface of the fruit, leaving only the thin epidermis. It is this with the tissue eaten away below that forms the characteristic gray area. Having completed its burrow to the surface the larva retreats a short dis-

tance and transforms to the pupa, inclosed in a puparium that looks much like that of the Mediterranean fruit fly. In ripe fruits, however, the larva leaves the fruit and pupates in the ground.

Because of the economical use made of all inferior fruit in the Mediterranean countries, infested olives are not a complete loss for they are used for oil that is used in the manufacture of soap. The olive fly would thrive in California and it would be even a more



Fig. 9.—Olive fly, *Dacus oleae* Rossi.

serious pest under our conditions because of the ripe-olive industry. All imported olives are pickled and thus there is little danger, but fresh olives, since they may contain all stages of the fly, should be closely guarded against.

#### FRUIT FLIES WELL ESTABLISHED IN THE UNITED STATES

There are several species of fruit flies in the United States, the most important of which are the apple maggot, *Rhagoletis pomonella* Walsh (fig. 11), and the cherry fruit flies, *R. cingulata* and *R. fausta* (fig. 10). Unlike the fruit flies thus far discussed, the above species may not be so threatening to California because they are restricted to the cooler parts of the United States. The apple maggot occurs north of the cotton belt and east of Montana, Wyoming, and Colorado.

The cherry fruit fly occurs across the northern United States and is in certain parts of Oregon. The mildness of a climate, however, constitutes a less certain barrier than does a rigorous climate, and we should be on the lookout for at least the cherry fruit fly.



Fig. 10.—Cherry fruit fly, *Rhagoletis fausta* O. S. (After Illingworth.)



Fig. 11.—Apple maggot, *Rhagoletis pomonella* Walsh. (After Guyton and Knull.)



## FRUIT FLIES IN CALIFORNIA

There are two species of trypetids in California at the present time that are of economic importance, namely, the currant fly, *Epochra canadensis* Loew (fig. 12), and the walnut husk fly, *Rhagoletis juglandis* Cress. (fig. 13). The larva of the currant fly is shown in figure 2B. It is about  $\frac{1}{4}$  of an inch long and creamy white in color. It may be distinguished from the larva of *Ceratitis capitata* by the difference in the anterior spiracles as shown in the figure. The adult fly is about



Fig. 12.—Currant fly, *Epochra canadensis* Loew. (After Whitney.)

the size of the house fly, with a general color of yellow or orange. They emerge from the soil, where they have remained as pupae from the previous year, in May and June, and deposit eggs singly in each fruit, and the larvae feed on the pulp of wild and cultivated currants and gooseberries.

The walnut husk fly is a recent introduction in California, having been taken near Chino in 1926. It was previously recorded from Arizona. This species is particularly abundant in the Eureka walnut, where as high as 90 per cent of the nuts may be infested, while the Placentia growing near by has thus far not exceeded an infestation of 3 or 4 per cent. The flies emerge late in July and August and the larvae may be found during the latter part of the walnut season in August, September, and October. The larvae feed on the husk entirely but because the shell is stained, and also the meat to a greater

or less extent as a result, the value of the nut is greatly reduced. The anterior spiracle has a larger number of tubules than *Ceratitis capitata* and is different in shape as shown in figure 2A and B. The host plants are limited to the different species of walnut.



Fig. 13.—Walnut husk fly, *Rhagoletis juglandis* Cress.

#### COMMON SCAVENGER FLIES IN DECAYED FRUIT IN CALIFORNIA

The larva of *Euxesta notata* Wied. (fig. 14) is commonly found in decayed fruits, nuts and vegetables and may easily be mistaken on casual examination for that of the Mediterranean fruit fly. Upon examination of the posterior spiracle, however, the difference is at

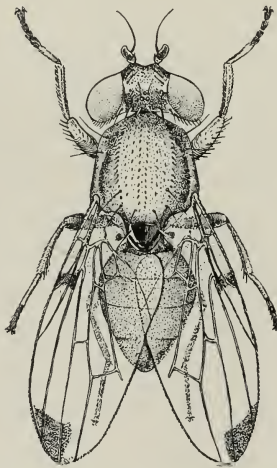


Fig. 14.—Scavenger fly, *Euxesta notata* Wied.

once apparent. In this and other species of scavenger flies the posterior spiracle is on the end of a short stalk as shown in figure 2C. Sometimes true fruit fly larvae may show some indication of a stalk if the fluid in which they are preserved tends to shrink the body, but the stalk is never so prominent as in the scavenger flies.

*Lonchaea occidentalis* is another scavenger fly that breeds in fruit in California. The larva is smaller than that of *Euxesta notata* or that of the Mediterranean fruit fly. The posterior spiracle is similar to that of *Euxesta*, but the anterior spiracle is different, as shown in figure 2C.

*Drosophila ampelophila*, or common pomace fly, is common in all fermenting fruits but the larva of this species (figure 2C) is very different from the other dipterous larvae found in fruits.

#### SCAVENGER BEETLE IN DECAYED FRUITS

The dried fruit beetle, *Carpophilus hemipterus* Linn. is one of the commonest insects found in decayed fruits in California. It infests fruits on the tree with only a small abrasion in the skin, as well as fruit in all stages of decay on the ground. The larva, especially in its younger stages, may at first be mistaken for that of the Mediterranean fruit fly. The mature larva is slender, of uniform thickness,  $\frac{1}{4}$  of an inch long and tipped with brown at both ends; these characters will readily distinguish it from that of the Mediterranean fruit fly. Beetle larvae also have three distinct pairs of legs and biting mouth parts, while fruit fly larvae have no legs and their mouth parts consist of mouth hooks.

#### WHAT TO DO WITH LARVAE FOUND IN FRUITS

Larvae found in fruits, nuts, or vegetables should be placed in about 50 per cent alcohol or 2 per cent formalin and sent to the University of California at Berkeley or Riverside, to the State Department of Agriculture, Sacramento, or to the County Horticultural Commissioner. Larvae are better preserved if they are first killed in boiling water and then placed for a few hours each in 25 per cent, 50 per cent, and 75 per cent alcohol.

## FLESHY-FRUITED CALIFORNIA PLANTS

As bearing upon a possible campaign of eradication in case the Mediterranean fruit fly may be found in the state at some time, it would be very important to know the wild or native plants that might serve as hosts. Through the courtesy of Dr. H. M. Hall of the Carnegie Institution there is presented below a list of native plants with fleshy fruits that would come in this category.

NOTE.—Species occurring in the mountains above the fruit belt are omitted; also all species with fruits smaller than currants.

S = small-fruited, *i.e.*, up to about the size of a gooseberry.

## LILIACEAE (Lily family)—

*Smilacina sessilifolia.* S

*S. amplexicaulis.* S

## LORANTHACEAE (Mistletoe family)—

*Phoradendron flavescens.* Mistletoe. S

*P. villosum.*

(Several additional species of mistletoe with small berries.)

## AIZOACEAE—

*Mesembrianthemum nodiflorum.*

*M. crystallinum.* Ice plant.

*M. aequilaterale.* Sea fig.

*M. edule.*

## RANUNCULACEAE (Buttercup family)—

*Actaea spicata.* Baneberry. S

## BERBERIDACEAE (Barberry family)—

*Berberis californica.* Barberry. S

*B. aquifolium.* Mountain grape. S

(Several other species of Barberry with small fruits.)

## LAURACEAE (Laurel family)—

*Umbellularia californica.* California laurel.

## SAXIFRAGACEAE (Saxifrage family)—

*Ribes aureum.* Golden currant. S

*R. sanguineum.* Wild currant. S

*R. malvaceum.* Chaparral currant. S

*R. divaricatum.* Wild gooseberry. S

*R. roezli.* Wild gooseberry.

*R. californicum.* Wild gooseberry. S

(Many more species of currants and gooseberries, especially in the mountains.)

## ROSACEAE (Rose family)—

*Rubus parviflorus.* Thimble-berry. S

*R. spectabilis.* Salmon-berry. S

*R. leucodermis.* Western raspberry. S



- R. vitifolius*. California blackberry. S  
*Fragaria chilensis*. Sand strawberry.  
*F. californica*. Wood strawberry.  
*Osmaronia cerasiformis*. Oso berry. S  
*Prunus demissa*. Choke-cherry. S  
*Prunus subcordata*. Sierra plum (scarce).  
*Prunus ilicifolia*. Islay (south).  
*Photinia arbutifolia*. Christmas berry. S.  
*Pyrus rivularis*. Oregon crabapple (north).  
*Crataegus douglasi*. Western black haw (north).  
*Peraphyllum ramosissimum*. S.  
*Amelanchier alnifolia*. Western service berry (mountains). S

## VITACEAE (Grape family)—

- Vitis californica*. California wild grape. S  
*V. girdiana*. Desert grape. S

## CACTACEAE (Cactus family)—

- Opuntia*. Prickly pear (south). (Some 18 or 20 species of *Opuntia*.)  
*Cereus emoryi* (coastal).  
(Three other species in the deserts.)  
*Echinocactus* (four or five species in the deserts.) S  
*Mamillaria* (five species). S

## CUCURBITACEAE (Squash family)—

- Cucurbita foetidissima*. Wild gourd (south).  
*C. palmata*. Wild gourd (south).

## ELAEOAGNACEAE (Oleaster family)—

- Shepherdia argentea*. Buffalo berry. S

## ERICACEAE (Heath family)—

- Arbutus menziesi*. Madroña.  
*Arctostaphylos* (many species but all with small fruits).  
*Vaccinium ovatum*. California huckleberry. S

## SOLANACEAE (Nightshade family)—

- Solanum nigrum*. Black nightshade. S  
*S. umbelliferum*. Blue-flowered nightshade. S  
*S. xanti*. S  
*Lycium pallidum* (desert). S  
*L. californicum* (desert). S  
*L. fremonti* (desert). S  
*L. cooperi* (desert). S  
*L. torreyi*. S  
*L. richi*. S

- Physalis crassifolia*. Ground-cherry (deserts).  
*P. ixocarpa*. Ground-cherry.

(Several other rare species of *Physalis*.)

